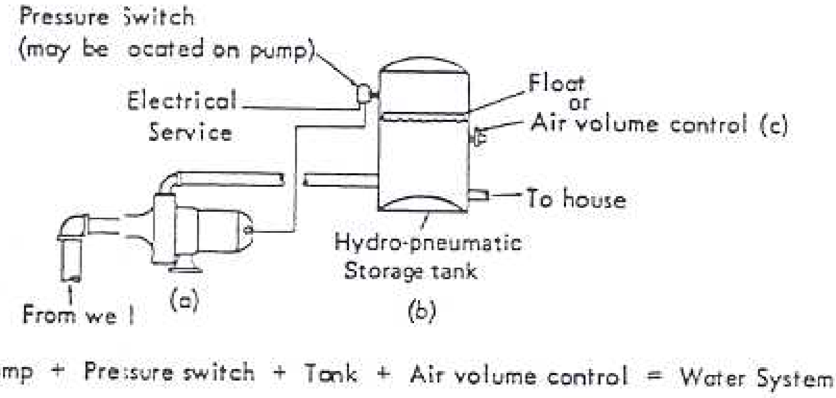
The private water system is made up of a pump, a storage tank, and accessories to operate the system automatically. One arrangement is shown schematically in Figure 2-1.

The pump may be one of several types: jet, submersible or reciprocating. The pump basically delivers the water from the well or other water source to a tank where it is held under pressure. Section (a) of Figure 2-1 shows a typical shallow well jet pump. (The term "pump" usually refers to both the pump itself and an electric motor which together make up the pumping unit. A gasoline engine could be used, but the almost universal availability of electric power makes this the usual energy source.)



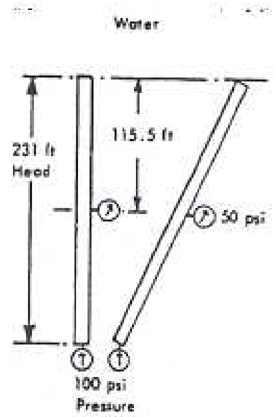

**Basic parts of automatic water system (Figure 2-1) are: (a) pump—a jet unit is shown here, (b) hydro-pneumatic storage tank, and (c) a device for controlling air volume in the storage tank, plus a pressure switch.**

<u>Height and water pressure are interrelated</u>. Because liquid has weight, it exerts pressure. Because it has weight, it requires power to move it. And when it moves, friction uses power, resulting in a loss of pressure. These characteristics are all related in a simple fashion.

Water has weight, so if we filled a pipe we would have to close the end to keep it in the pipe. If we filled a pipe 231 feet high and one inch square, the weight of water on the bottom of the pipe would be 100 pounds. For any size pipe 231 feet high, the weight or pressure of water in the pipe would be one hundred pounds psi.

We live at the bottom of a sea of air. There is about twenty five miles of air above us. And because it has weight it exerts pressure - 14.7 psi at sea level. As one goes up on a mountain or in an airplane. the pressure decreases as the height of air above is less.

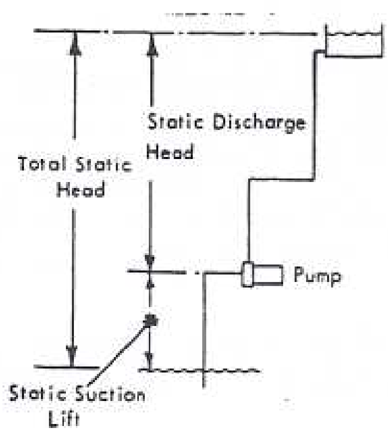
Thus, it appears that pressure and height are related. When pressure is expressed in height, it is called "head." For water, 2.31 feet of head is equivalent to one psi, and one foot of head is equivalent to .434 psi. In Figure 2-2, if the pressure were measured 115.5 feet up the pipe, the gauge would read fifty psi. Note also that in the slanted pipe the reading would be the same. Pressure, therefore, depends on elevation.




**Schematic illustration (Figure 2-2) of the relationship between height and pressure. A column of water 231 feet high exerts 100 psi pressure—whether the column is vertical or tilted.**

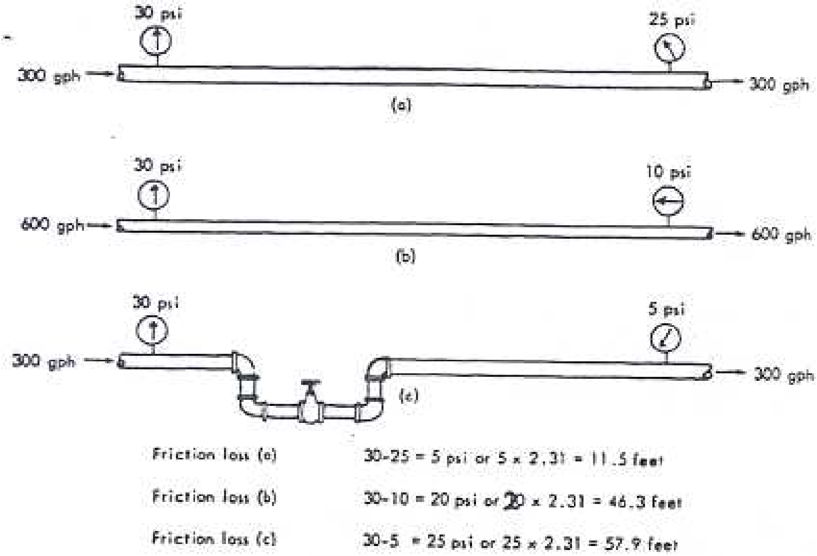
"Head" is pressure expressed in height. Pressure can be shown as the difference in elevation, and as such is normally called "head." When no water is flowing, the head is called static head. If the elevation is on the suction side of the pump, it is called static suction lift and is expressed in feet. On the discharge side it is static discharge head, and may be expressed in feet or pounds. The two together make up total static head. These terms are illustrated in Figure 2-3.

Flow is measured in volume moved in a given length of time. Commonly, this is gallons per minute (gpm) or gallons per hour (gph). Gpm is used for smaller amounts, gph is for large water flows.

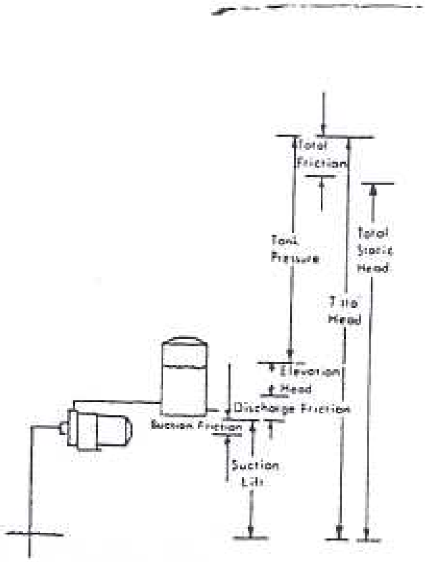



**Total static head (Figure 2-3) consists of the difference in elevation of water levels on suction and discharge sides of the pump.**

Friction caused by flow increases total head. When liquid moves through a pipe, it must overcome resistance caused by friction from both its sliding along the pipe walls and its own turbulence. For this reason, if pressures were recorded in a length of pipe such as shown in Figure 2-4, the gauge at the inlet would show a higher reading than at the outlet. Unfortunately, as the flow rate increases, the pressure drop increases rapidly. If the flow doubles, the pressure drop increases four times. Obviously, smaller pipe shows higher friction loss as the same flow. Fittings which introduce turbulence also increase the friction losses.




**As shown by these sketches (Figure 2-4), pressure loss from friction increases with either the flow rate (b) or fittings which increase the water's turbulence (c).**



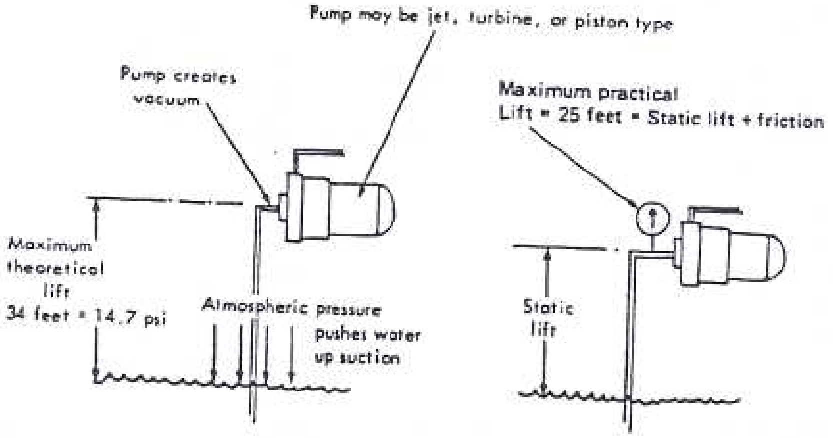

**Schematic illustration (Figure 2-5) of total head and the various components of which it consists.**

Power requirements increase with higher flow rates and greater friction losses. Whether we lift a gallon of water to a higher level or push it against friction, power is required. This power depends on the flow rate and the pressure or head the liquid moves against. Any power used up to overcome pipe friction is not available to move more water or develop greater head.

Total head combines static and friction heads. As shown previously, when water flows there is a loss of pressure. This loss is called friction head. This must be added to the static head to make total head. For a pumping system, it is the total head which governs pump selection as far as pressure is concerned. In the case of a pneumatic tank, the pressure in psi is converted to head in feet and this then becomes the discharge head. Figure 2-5 shows the total head and its various components, graphically.

To convert feet of head to pressure in pounds, multiply by .434. To convert pressure in pounds to feet of head, multiply by 2.31.

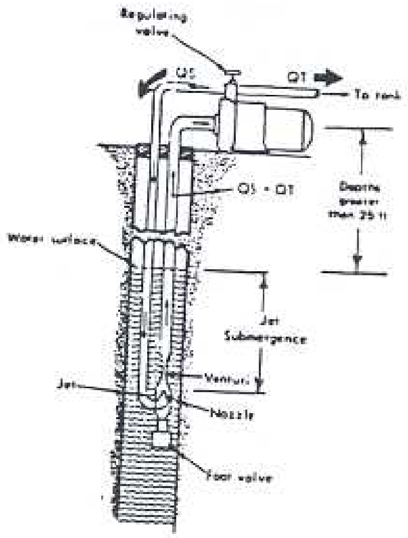
Shallow well pumps use atmospheric pressure. A shallow well pump is one which produces lower than atmospheric pressure at its inlet. If the inlet is submerged in the water in a well (Figure 2-6), atmospheric pressure will force the water up to the suction pipe.



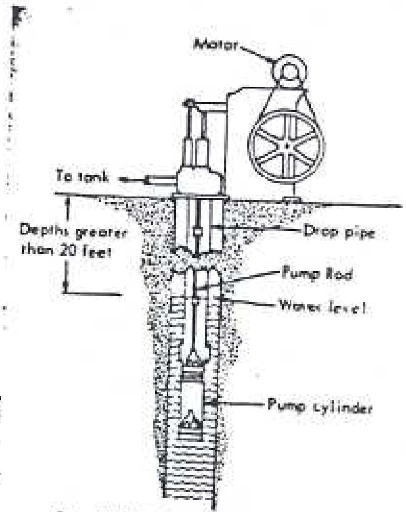

**Shallow well pumps (Figure 2-6) operate by creating a partial vacuum at the surface. Atmospheric pressure forces water into this vacuum. In theory, shallow well units could lift water 34 feet. But because of friction loss and limited pump efficiency, the maximum practical lift is twenty-five feet.**

Theoretically, if the pump could create a perfect vacuum at sea level, water could be drawn up thirty-four feet (14.7 x 2.31). Practically, this is not possible because the pump cannot create a perfect vacuum and there is friction loss in the suction pipe. The normal limit is twenty-five feet of suction lift, i.e., the difference in elevation between the water in the well, and the pump plus any friction losses in the pipe. The two must be taken together as the pump has no way of knowing whether its suction lift comes from elevation or friction and elevation. Pump manufacturers indicate capacity their pumps give at a given suction and this lift is elevation plus friction. Note: Up in the mountains where atmospheric pressure is lower, the suction lift must be lowered. This reduction is about one foot for each 1,000 feet of elevation above sea level.

Deep well pumps push water to surface. When water is at levels below the suction limits, then another pumping system must be used. This is the deep well system. This system locates at least part of the pumping mechanism submerged in the well water. The unit could be a jet, a deep well reciprocating pump, or a multi-stage centrifugal pump.

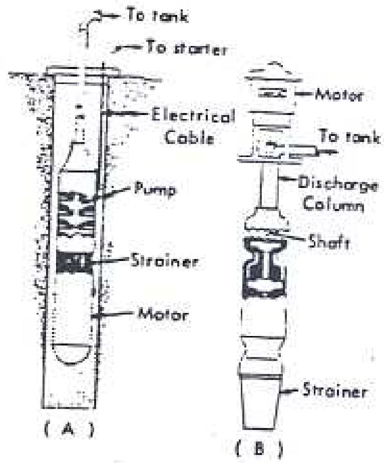



Deep well jets (Figure 2-7) function by forcing water (QS) through the nozzle and venturi of a jet or ejector. This creates suction which lifts well water (QT). Both flow back to the pump. Then some water is returned to operate the jet; the remainder flows to the pressure tank.




Deep Well Working Head and Cylinder

Deep well working heads (Figure 2-8) have a power source at the surface connected by rods to a submerged cylinder. Alternate up and down movement of the cylinder forces water to the surface.




Deep well centrifugal pumps (Figure 2-9) may be of two types: (A) shows the submersible unit, in which both motor and pump mechanism are submerged in well water. In the case of a vertical turbine (B), the pump unit is connected to a motor at the surface by means of a vertical shaft.

In the case of the deep well jet shown in Figure 2-7, a centrifugal pump at the surface sends water down to the jet or ejector submerged in the well water. This jet creates suction which picks up well water and forces it to the surface. The combined flow passes through the pump. Part then goes back to operate the jet; the rest flows to the tank or point of consumption.

The deep well reciprocating pump consists of a working head at the surface which operates through a set of rods and cylinder located submerged in the well water. The cylinder pushes water to the surface (Figure 2-8.)

The centrifugal pump can be made long and slender by assembling impellers and bowls (or diffusers) in pancake fashion. Such a unit can be operated by a submerged motor, in which case it is called a submersible pump. Or the impellers and bowls can be connected by shafting to a motor at the surface, as in the case of a vertical turbine. In either case, the pump pushes the water to the surface. Figure 2-9 shows these two types of pumps.

## TYPES & CHARACTERISTICS OF PUMPS USED IN PRIVATE WATER SUPPLY SYSTEMS

| Type of Well | Type of Pump | Normal Capacity Range (Gallons Per Hour) | Practical Suction Lift* (Feet) | Max. Practical Pumping Depth (Feet) | Usual Discharge Pressure Range (PSI) | Remarks |
|---|---|---|---|---|---|---|
| Shallow Well | Shallow Well Jet (Ejector On Pump) | 200-1500 | 20-25 | 25 | 20-40<br>30-50 | 1. Type most widely used.<br>2. Simple in construction.<br>3. Easy to service.<br>4. Need not be located over well.<br>5. Inefficient hydraulics. |
| Shallow Well | Piston Or Reciprocating | 200-800 | 20-25 | 25 | 20-40<br>30-50<br>40-60 | 1. Adaptable to low capacity & high head.<br>2. Handles air without losing prime.<br>3. No longer widely used. |
| Shallow Well | Submersible | 200-300 | Pump & Motor Submerged | Beyond Shallow Wells | 30-50<br>40-60<br>50-70 | 1. Will produce high heads.<br>2. Adaptable to frost proof installations.<br>3. Efficient hydraulics.<br>4. Quiet operation.<br>5. Can be used only in 3" or larger wells. |
| Shallow Well | Straight Centrifugal (Single & Multi Stage) | 500-2000 | 15-20 | 20 | 20-40<br>30-50 | 1. Suitable for high capacities.<br>2. Efficient hydraulics.<br>3. Primes poorly—loses prime easily.<br>4. Simple & easy to service. |
| Deep Well | Deep Well Jet (Single & Multi Stage) (Ejector In Well) | 200-1000 | 15-20 Feet Below Ejector | 180 | 20-40<br>30-50<br>40-60 | 1. Simple in construction & operation.<br>2. No moving parts in well.<br>3. Inefficient hydraulics.<br>4. Can be installed in 2" & 3" wells.<br>5. Can be located away from well. |
| Deep Well | Submersible | 200-3000 | Pump & Motor Submerged | 1000 | 30-50<br>40-60<br>50-70 | 1. Suitable for deep settings.<br>2. Adaptable to frost proof installations.<br>3. Efficient hydraulics.<br>4. Available in wide range of heads & capacities.<br>5. Can be used only in 3" or larger wells. |

*Practical suction at sea level. Reduce 1 foot for each 1000 feet above sea level.

### Criteria for pump selection

1. Adequate capacity (gpm) for present and future usage.
2. Adequate pressure for the present and future usage and for the possibility of a lower water level in the well.
3. Cost of pump.
4. Cost of labor to install pump.
5. Cost of materials to install pump (piping, fittings, accessories, well pit, etc.).
6. Area needed to install pump. Is space available?
7. Reliability of pump.
8. Cost of servicing pump.
9. Ease of servicing pump. Can it be repaired in the field, or in dealer's repair shop, or does it have to be returned to the factor?
10. Cost of operating the pump (power and parts costs).
11. Flexibility of the pump for various types of installations common in a given area.

## Criteria for Sizing a Pump

1. Size of well
2. Depth of well
3. Capacity of well
4. Pumping level
5. Capacity required by the user
6. Discharge pressure required

(1) Size of the Well

This is very important as most submersibles on the market today requires a minimum well diameter of 4 inches. Even in a 4" well, it is necessary that the well be almost perfectly straight. Myers 4" submersible pumps have a maximum O.D. (outer diameter) of 3-78", including the cable guard. Other manufacturers are very near this, either larger or smaller.

(2) Depth of Well

This is imppportant for two reasons: One, the pump must not be lowered into any mud, sand or gravel that might be in the bottom of the well. There is a possibility of ruining both the pump and motor if this is done. Secondly, by knowing the depth of the well, the depth of pump setting can be used to control the flow of water.

(3) Capacity of the Well

This is usually the most important factor in selecting a pump. If a well produces only 1 GPM, there is no use putting a pump into it that will pump 15 GPM. There are certain applications where this is done. But, there must be some type of control involved to keep the pump from pumping the well dry.

(4) Pumping Level

Now this should not be mistaken to mean static water level. Pumping level is the lowest level of the water in the well with the pump running. In many cases this is not known until after the pump is installed, but the driller will usually have a good idea where it is. The capacity of the pump installed will make this vary.

(5) Capacity Required by the User

This usually should be determined by the dealer. The average homeowner doesn't realize how much water he uses. Generally he will expect the dealer to guide him in his selction of a pump, after it is explained to him how much water is required for his uses. These figures can be found in the Engineering section of the Myers Catalog for average usage. It will have to be determined whether or not these figures apply in each individual case. Always allow for growth, such as additions to the family, additional water using appliances, etc.

(6) Discharge Pressure Required

Low pressure is a common complaint among homeowners who have outdated water systems. With the new appliances on the market now, the required discharge pressure is gradually moving up. It is not all uncommon to find homes with pressures on their water systems of 30-50, or 40-60. Especially if they have a two story house with a bathroom upstairs. Pipe sizes used in the plumbing of a house affects the required discharge pressure. Normally, the smaller the plumbing pipe size, the higher is the required pressure switch setting. If there is a long run such as to a barn or cattle shed several hundred feet away, there must be enough pressure to overcome the friction in the pipe and still give satisfactory pressure at the other end.

If these six items are known, the pump can be easily selected from pump catalog selection charts. Select a water system with enough capacity to meet both present and future requirements. A pump of greater capacity than that of the well should not be installed unless some method of controlling pump flow is used. If well draws down to pump inlet, air enters the pump and can result in air binding and vibration. Damage can result from operation under these conditions.

There are three methods of controlling pump capacity on weak wells:

1. Flow valve method
2. Depth of pump setting
3. Liquid level controls

(1) Flow Valve Method

A simple way to prevent drawdown to pump inlet is to throttle the pump discharge to capacity equal to well yield. The best method of throttling is to use a Dole Flow Valve. A Dole Flow Valve delivers a constant capacity regardless of pump discharge pressure. The flow valve is installed in the discharge line, between the pump and the pressure tank. The usual way to determine what size of flow valve to use is to throttle the discharge gate valve to a capacity that the well will yield without drawing down to pump inlet. After pump has operated at this capacity for a sufficient time to be sure it is suitable, measure the flow in GPM and select a flow valve size nearest to this capacity. Install the flow valve and recheck to be sure operation is satisfactory. The one disadvantage to this method is that since the flow from the pump is equal to what the well is producing, the benefits of having a reservoir of water in the well is lost.

(2) Depth of Pump Setting

If a well is of sufficient depth, the pump can be installed to a depth of 5 to 10 ft. more than the maximum delivery head of the unit thereby making it impossible to pull the water down to the inlet screen.

If for some reason a larger pump is installed, by including a diaphragm type pressure regulator in the discharge line at the top of the well, additional head can be added against the unit. This gives the same effect as setting the pump deeper in the well, thus eleiminating the possiblity of pumping the well down and drawing air into the unit.

(3) Fluid Level Controls

A liquid level control is an electrical device which disconnects power to the pump when the water level in the well reaches a predetermined low point. Electrodes can be installed in the well so that pump will be shut off when water level reaches a point of 5 to 10 ft. above the inlet screen. One electrode is installed just above the pump and the other approximately ten feet higher. When water is drawn down to the lower electrode, power is shut off to the pump. The pump will not restart until water builds back to upper electrode. This control is completely automatic and gives satisfactory results.

DEFINITIONS

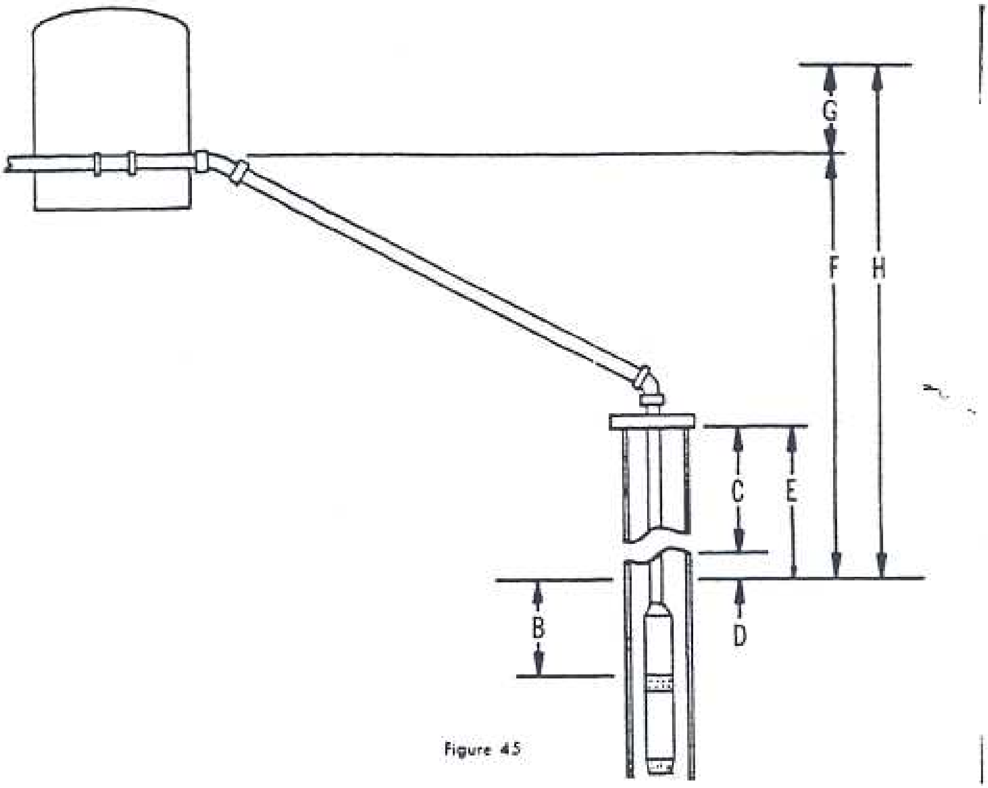



Figure 45

A. Capacity: Amount pumped in gallons per minute or gallons per hour, etc.

B. Submergence: Vertical distance from pumping water level to top of suction screen.

C. Static Water Level: Vertical distance from ground level to water level when not pumping.

D. Drawdown: Vertical distance the water level drops when pumping. Drawdown varies with the capacity of the well and pump.

E. Pumping Water Level: Vertical distance from ground level to water level when pumping (C plus D).

F. Discharge Head: Elevation and/or pressure. Does not include friction loss.

G. Friction Head: Loss in head due to friction of discharge pipe, fittings, etc.

H. Total Discharge Head: Elevation and/or pressure from pump to discharge including losses due to friction. (F plus G).

Ohmmeter: Instrument used to measure electrical resistance. Most commonly used to measure electrical resistance of a wire circuit. Unit of measure is ohm.

Amprobe: Combination instrument capable of measuring both voltage and amperage.